APPLICATION OF LANDSCAPE-SCALE HABITAT SUITABILTY MODELS TO BIRD CONSERVATION PLANNING

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Application of landscape-scale habitat suitability models to bird conservation planning

- Review concept of HSI
- Look at historical application
- Adapt HSI to landscape-scale, GIS-based applications for conservation planning

HSI model basics

- Numerical index of habitat suitability on a 0.0 to 1.0 scale
- Models can be based on published knowledge, data, expert opinion
- Documentation explains the model's structure, data sources, and assumptions
- Models should be viewed as hypotheses of species-habitat relationships
- Their value is to serve as a basis for improved decision making and increased understanding of habitat relationships; they specify hypotheses of habitat relationships that can be tested and improved.

Original HSI formulation

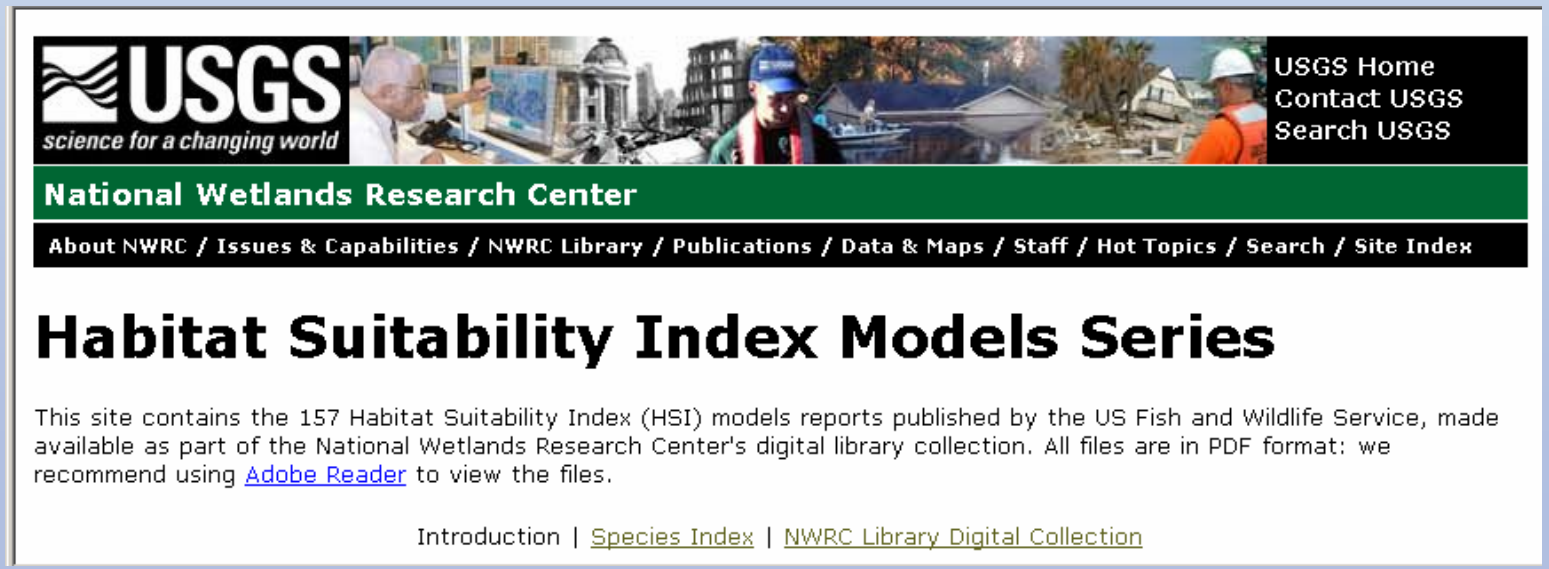
$$HSI = (V1 \times V2 \times V3)^{1/3}$$

V1….Vx = limiting factors or life requisites; if any one variable=0 then HSI = 0

USFWS HSI model series

- U.S. Fish and Wildlife Service. 1980a. Habitat Evaluation Procedures (HEP). USDI Fish and Wildlife Service. Division of Ecological Services. ESM 102.

- U.S. Fish and Wildlife Service. 1981. Standards for the development of habitat suitability index models for use in the Habitat Evaluation Procedures, USDI Fish and Wildife Service. Division of Ecological Services. ESM 103.



Biological Services Program
and
Division of Ecological Services

FWS/OBS-82/10.27
JULY 1982

HABITAT SUITABILITY INDEX MODELS: YELLOW WARBLER

Fish and Wildlife Service

U.S. Department of the Interior

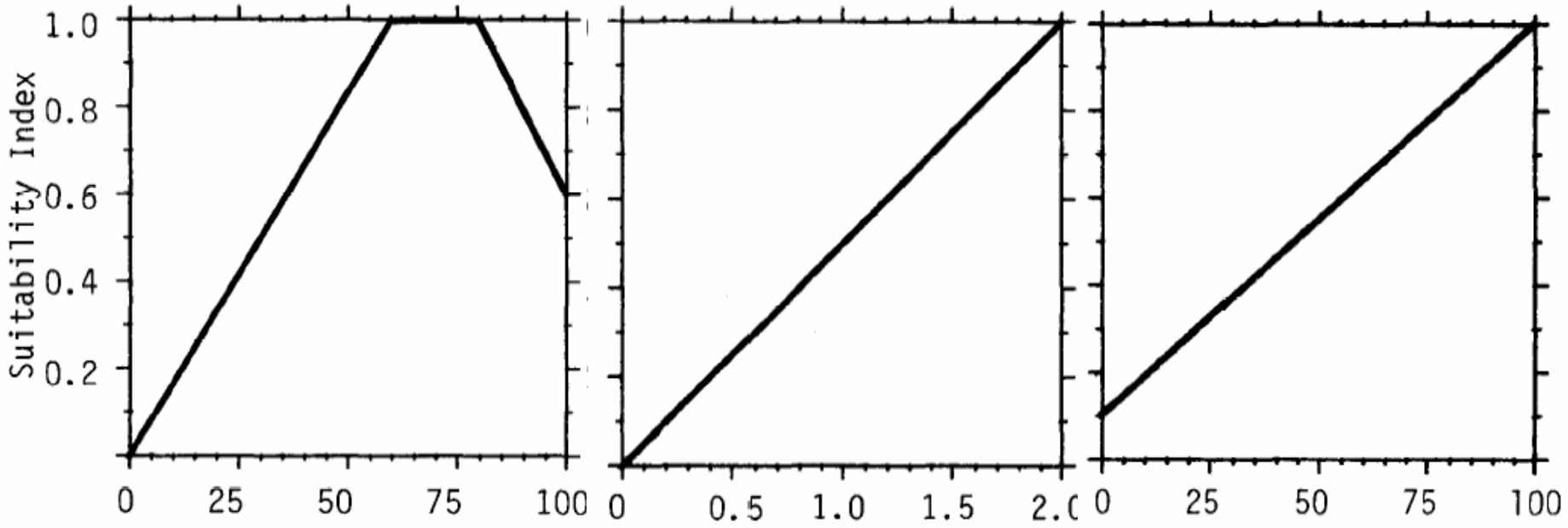
FWS/OBS-82/10.39
APRIL 1983

HABITAT SUITABILITY INDEX MODELS: PILEATED WOODPECKER

Fish and Wildlife Service

U.S. Department of the Interior

Yellow warbler HSI model (USFWS 1982)



% deciduous shrub cover

Mean height decid. shrub cover

% hydrophytic shrubs

$$HSI = (V_1 \times V_2 \times V_3)^{1/3}$$

HSI models for conservation planning

- Applicable to larger scales
- Applicable in GIS
- Utilize available data
- Address concepts of abundance and viability

Adapting HSI models to raster-based GIS

- SIs and HSI values calculated for each pixel
- Results in a new data layers representing maps of SI and HSI values
- SIs can be based on pixel attributes or attributes of surrounding pixels
- Can utilize wide range of GIS functions or landscape statistics
- HSI values can be summarized for the landscape

Acadian flycatcher HSI model (in development)

- SI_1: We considered birds to be densest (relative density = 1.000) in mature (Pagen et al. 2002) woody wetlands (Sallabanks et al. 2000) along floodplains and valleys (Klaus et al. 2005) and scarcest in sapling evergreen stands along xeric slopes and ridges.

Acadian flycatcher SI_1

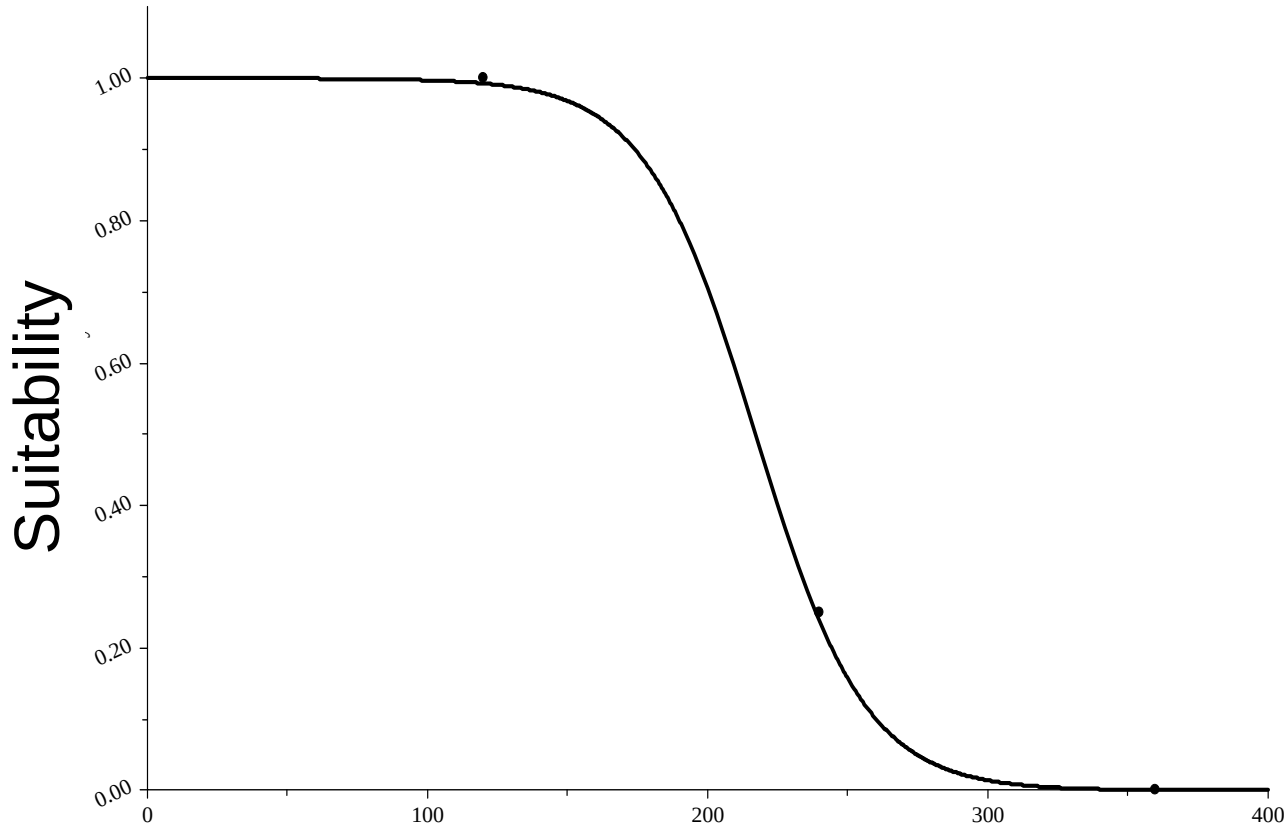
Table 1. Relationship between landform, forest type, age class, and relative density of Acadian flycatchers.

		Age class		
Landform	Forest type	Sapling	Pole	Sawtimber
Floodplain/valley	Woody wetlands	0.350	0.700	1.000
	Deciduous	0.315	0.630	0.900
	Mixed	0.210	0.420	0.600
	Evergreen	0.105	0.210	0.300

Acadian flycatcher HSI model (in development)

- SI_2: We fit an inverse logistic function to describe the relationship between Acadian relative density and increasing distance to water. Acadians normally align at least 1 edge of their 1-ha territory along a stream or wetland (Woolfenden et al. 2005).

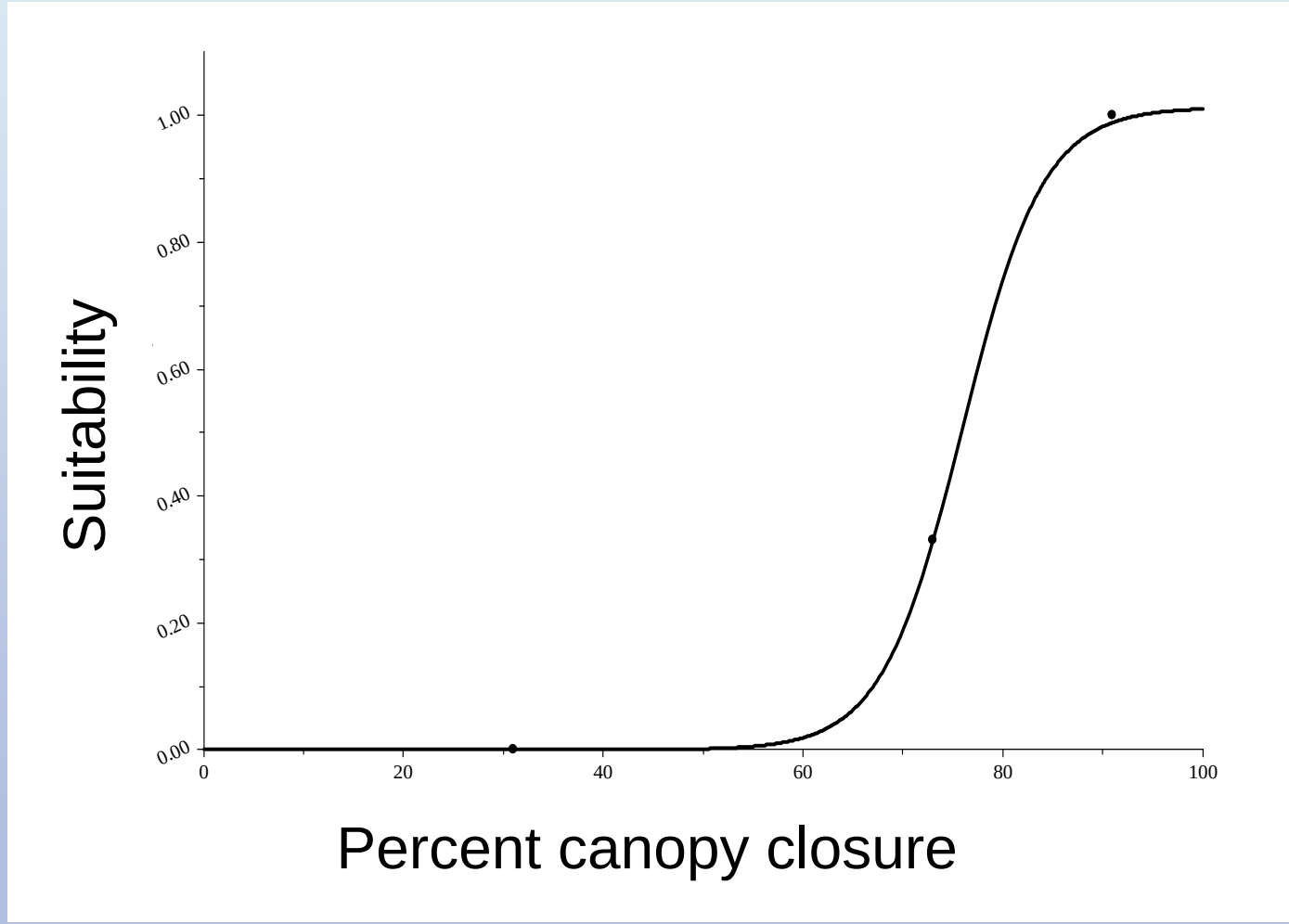
Acadian flycatcher SI_2



Acadian flycatcher HSI model (in development)

- SI_3: …..included canopy closure (SI3) because of its strong effect on Acadian flycatcher density (Prather and Smith 2002). …we utilized a smoothed logistic function to extrapolate between the known break points in the canopy cover-relative density relationship.

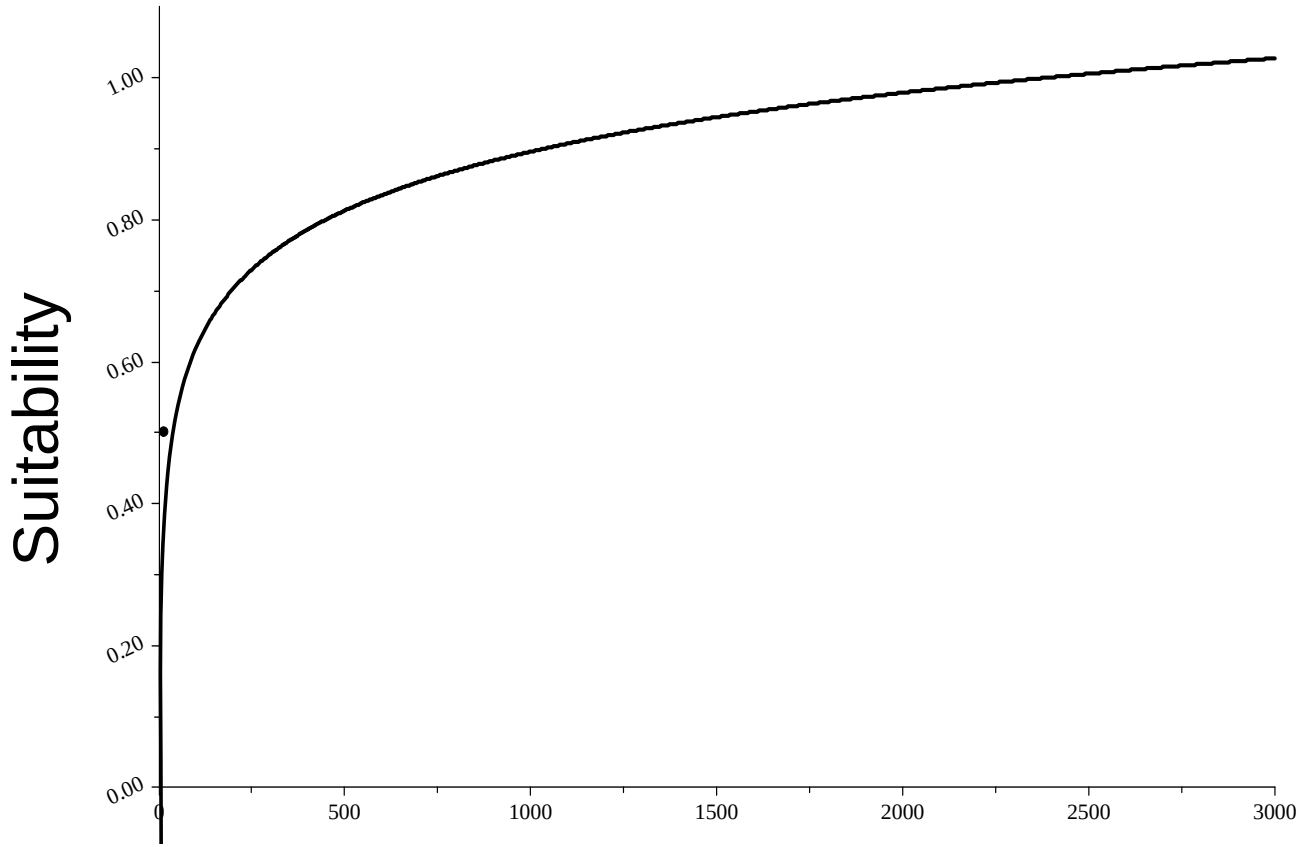
Acadian flycatcher SI_3



Acadian flycatcher HSI model (in development)

- SI_4: Forest patch size was included as a model factor because of the susceptibility of Acadian flycatchers to fragmentation (Robbins et al. 1989) and increasing edge density (Parker et al. 2005). We used a logarithmic function to describe the relatively quick increase in suitability of a forest patch as area increased (Robbins et al. 1989).

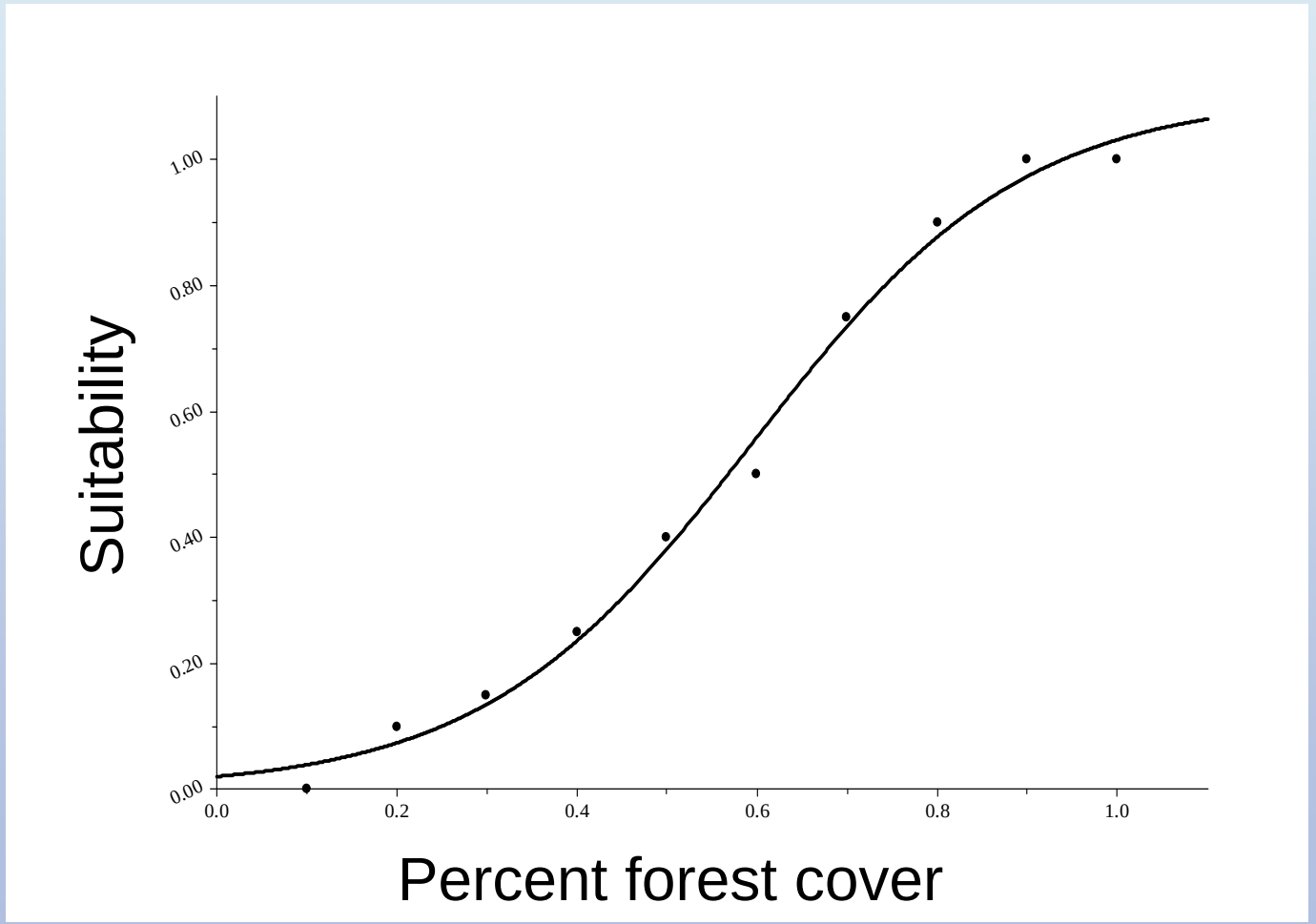
Acadian flycatcher SI_4



Acadian flycatcher HSI model (in development)

- $SI_{5:}$ This factor accounted for the higher parasitism (Robinson and Robinson 2001) and predation rates (Ford et al. 2001) of increasingly non-forested landscapes. The smoothed logistic function was derived from data collected by Ford et al. (2001) on the difference between sites 80 and 90% forested. The dramatic decline in productivity in increasingly non-forested landscapes was hypothesized from the edge avoidance of this species (Parker et al. 2005) and the absence of Acadians from small fragments (Robbins et al. 1989).

Acadian flycatcher SI_5



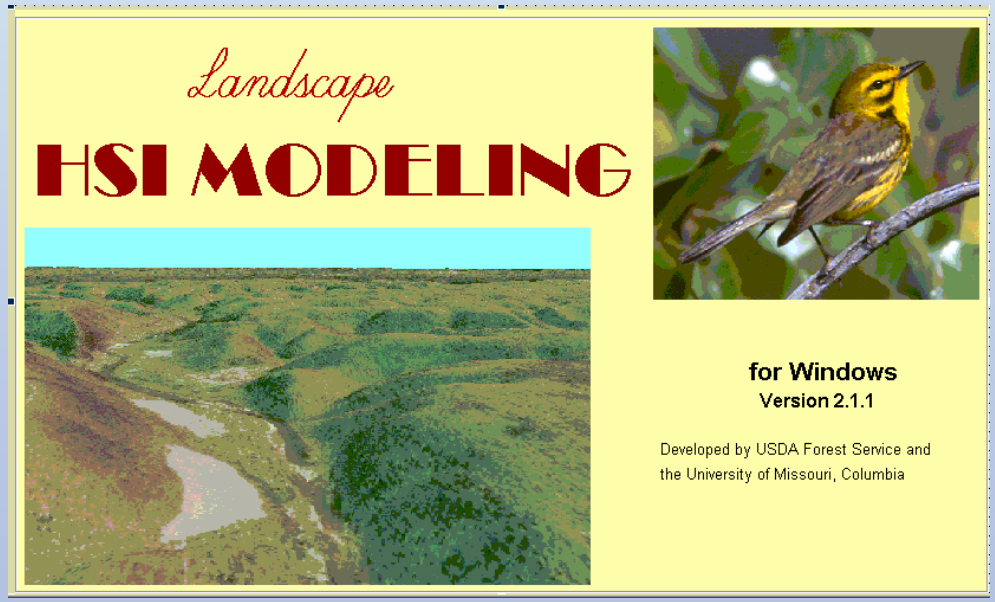
Acadian flycatcher HSI model (in development)

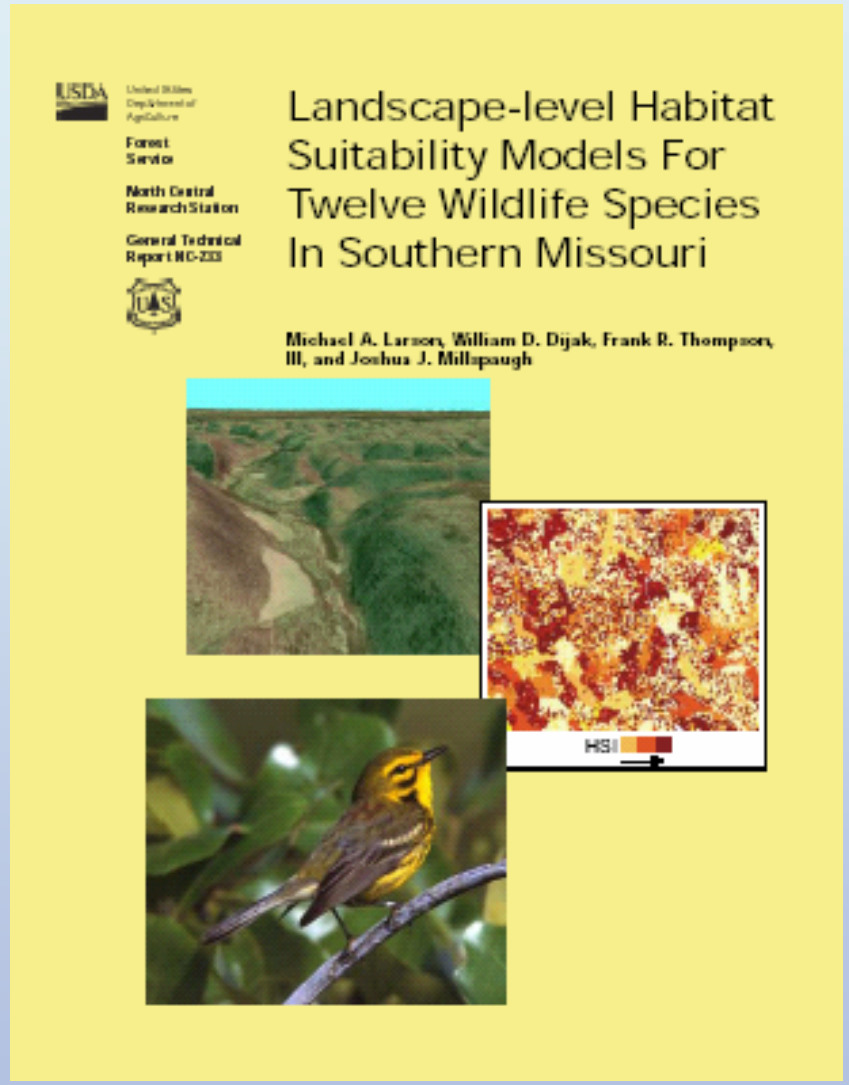
- SI_1: forest type and age-class
- SI_2: distance to water
- SI_3: canopy closure
- SI_4: patch size
- SI_5: percent forest cover

Relative density HSI = $((SI_1 * SI_2 * SI_3)^{1/3}) * SI_4$

Relative productivity HSI = SI_5

GIS-based HSI models





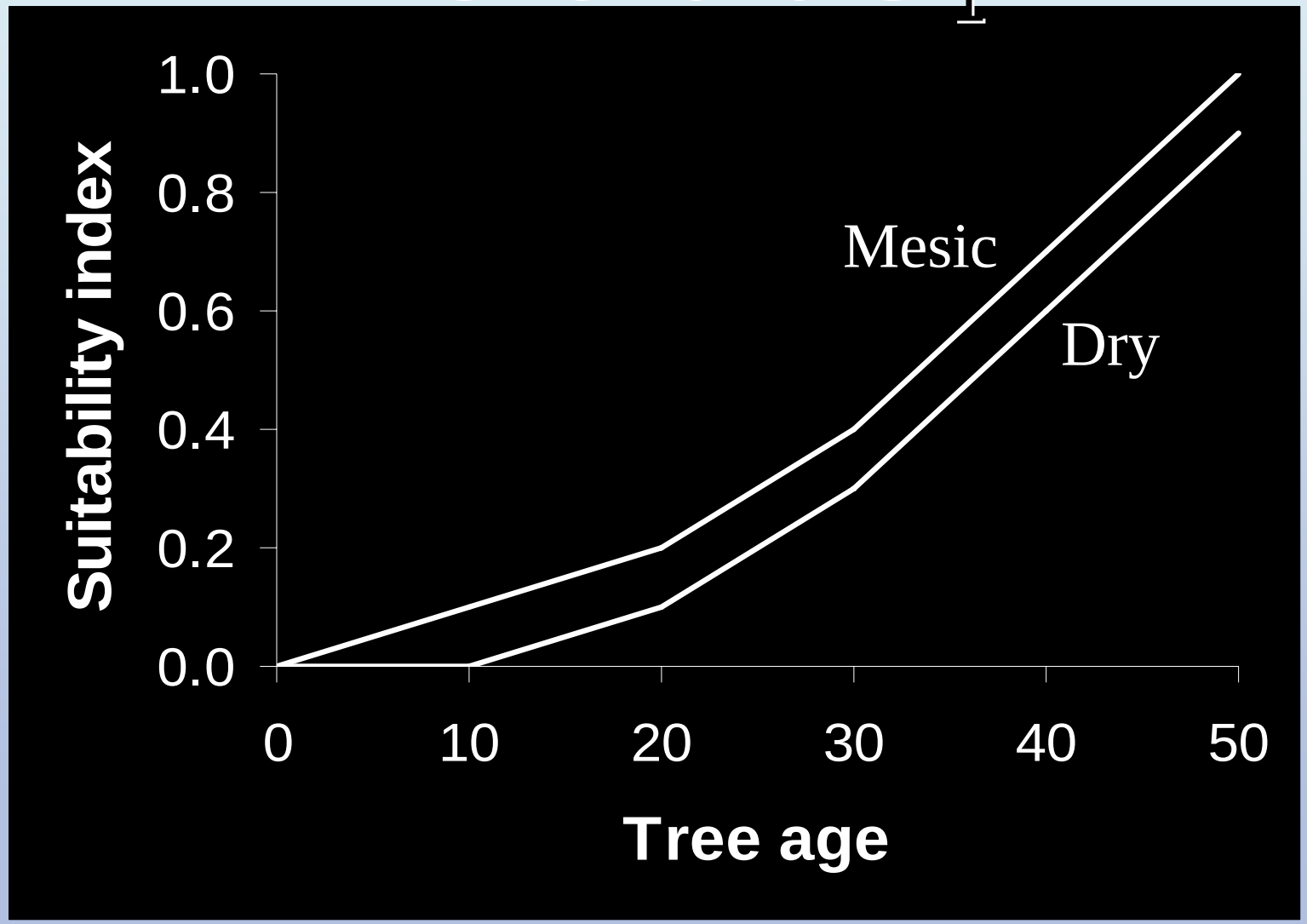
Ovenbird

- Mid-late successional forest species
- Area/edge sensitive

Illustration by Trevor Boyer, Linden Artists Ltd.

- GIS data layers
  - Forest-type groups
  - Forest/tree age class
  - Ecological land types based on landform

Ovenbird SI_1

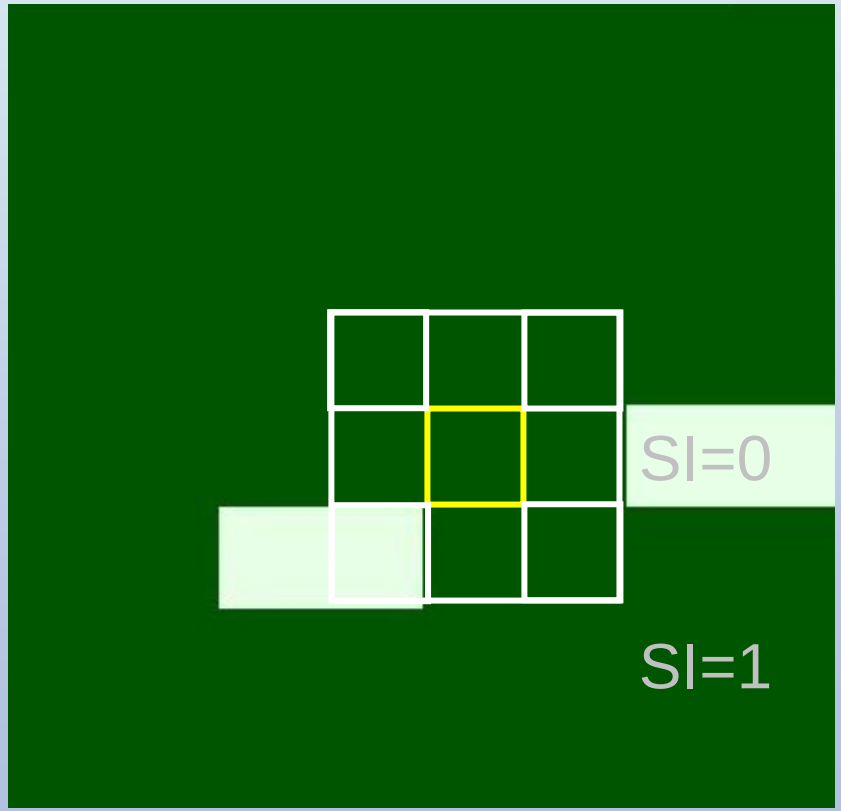


Ovenbird SI_2

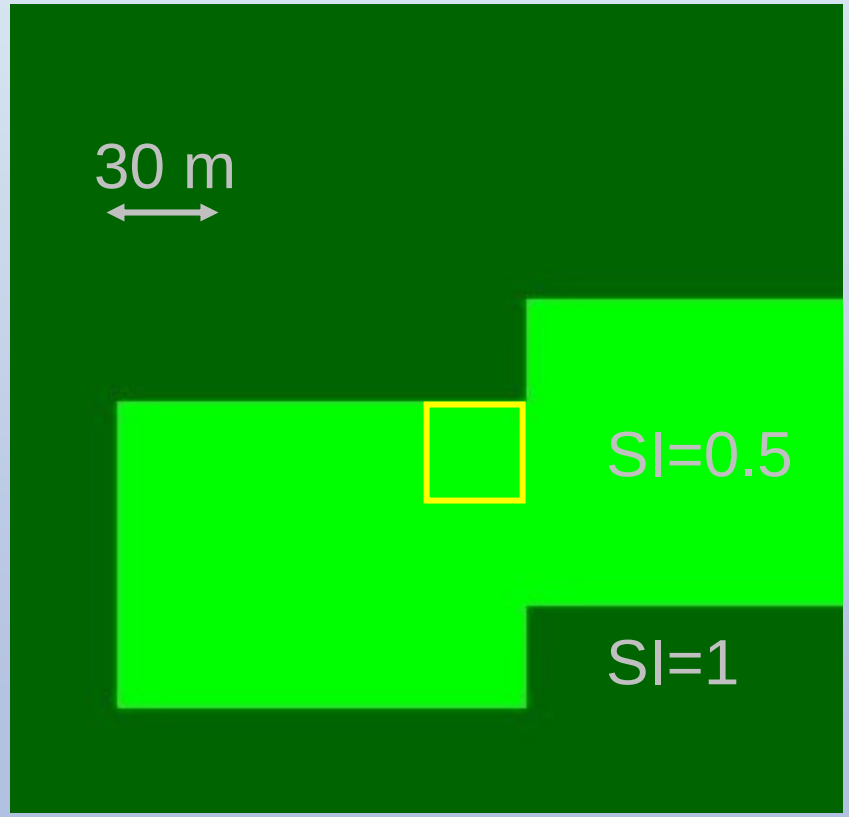
- If species = pine, then $SI_2 = 0$
- Otherwise, $SI_2 = 1$

Ovenbird SI_3

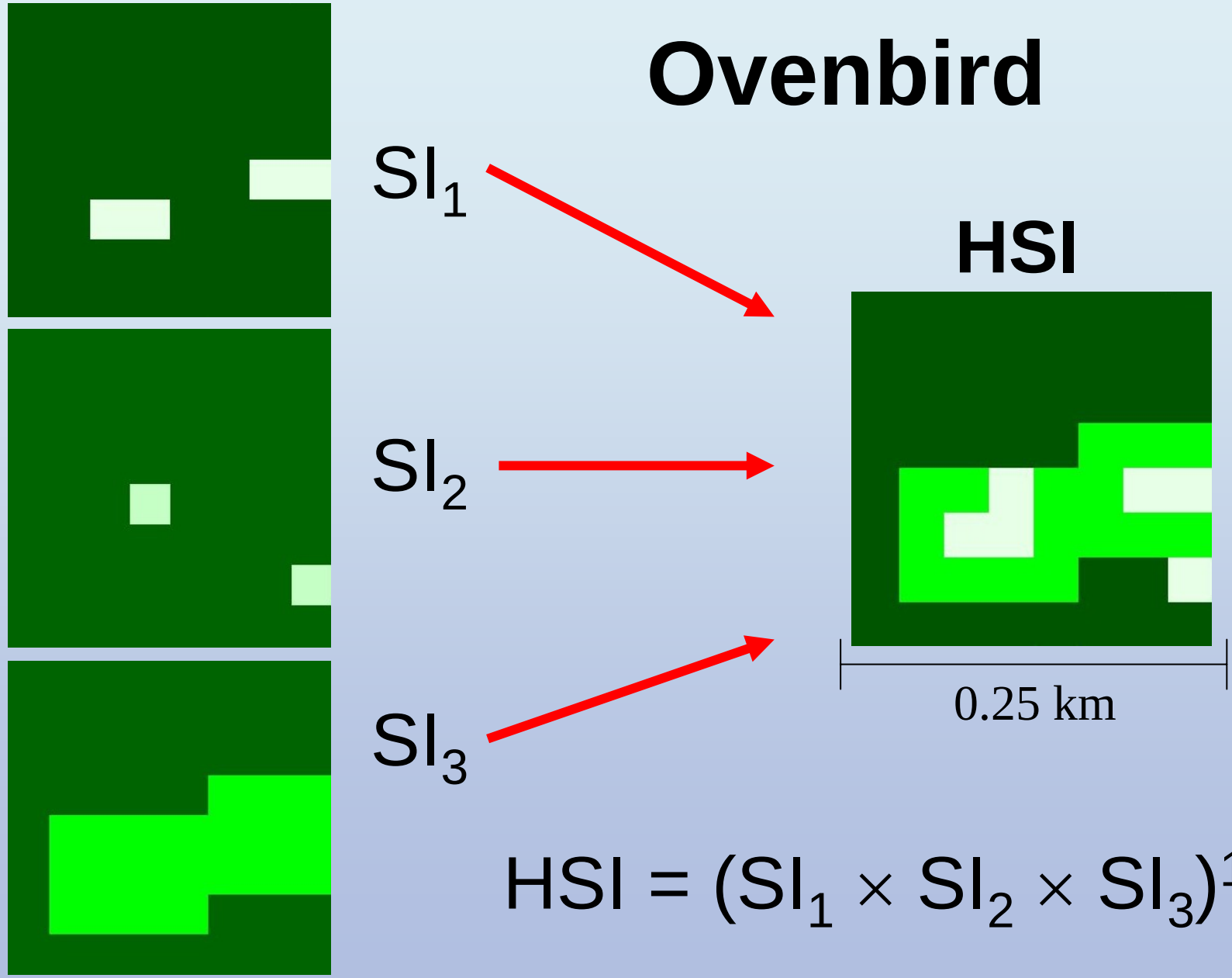
SI_1



SI_3



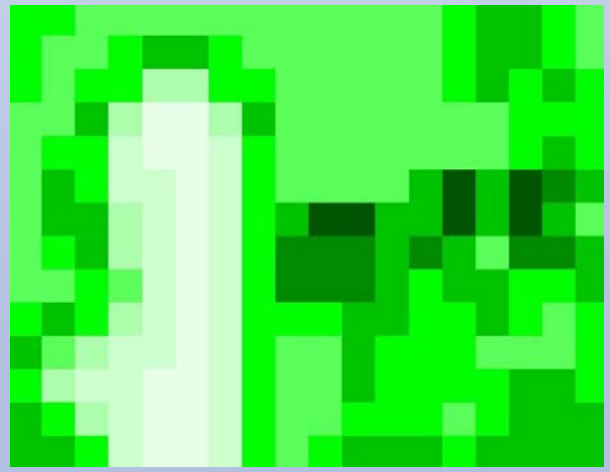
Ovenbird



$$HSI = (SI_1 \times SI_2 \times SI_3)^{1/3}$$

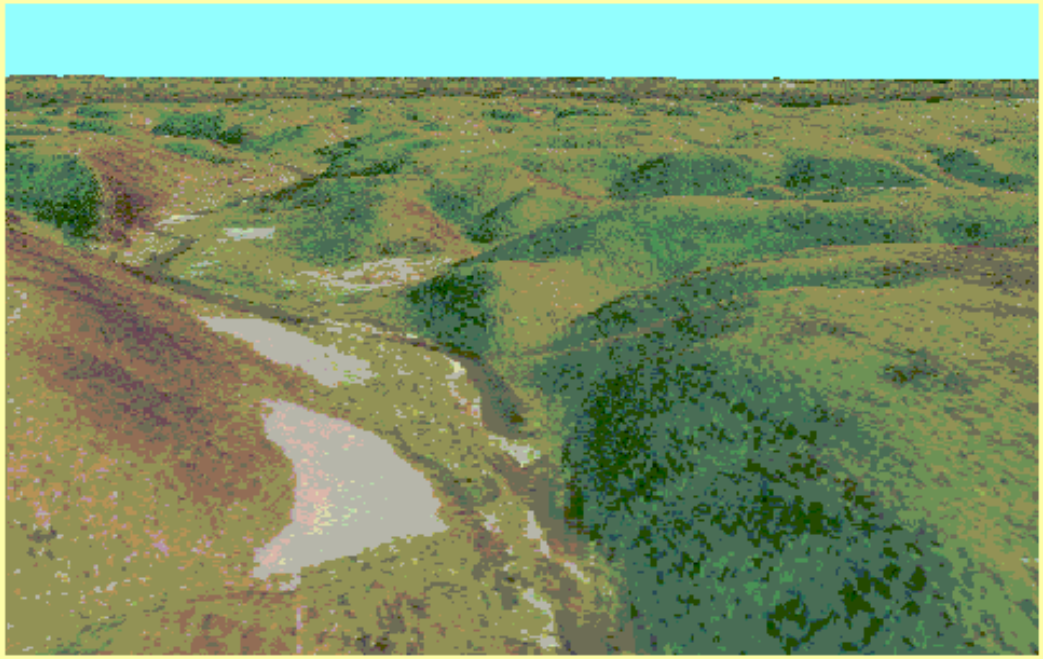
Ecological and landscape effects

- Area sensitivity
- Edge effects
- Interspersion
- Composition
- Juxtaposition of resources



Landscape

HSI MODELING



for Windows

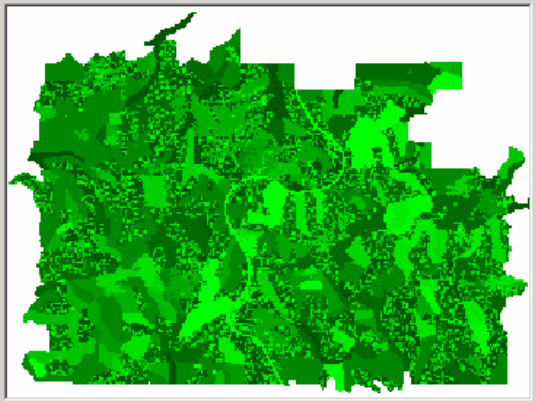
Version 2.1.1

Developed by USDA Forest Service and
the University of Missouri, Columbia

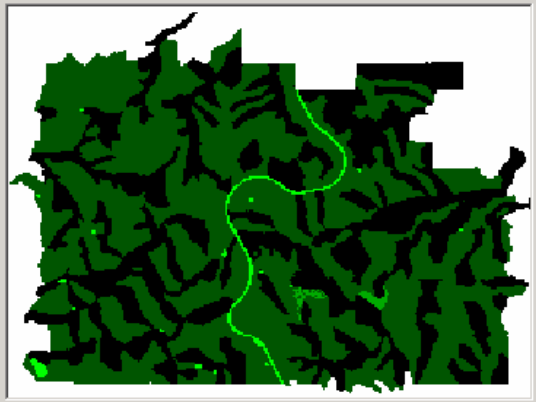
HSImodels - [Prairie Warbler HSI Model]

File View Models Window Help

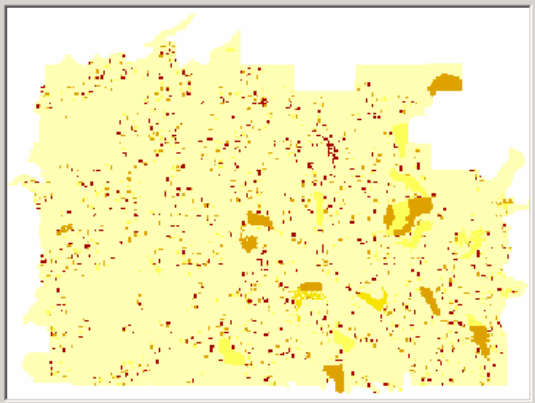
Prairie Warbler SI 1 | Prairie Warbler SI 2 | Prairie Warbler SI 3 | Prairie Warbler HSI



Add Tree Age Image



Add ELT Image



Calculate SI 1

☐ Write Output File

◉ Scale 0.0 - 1.0

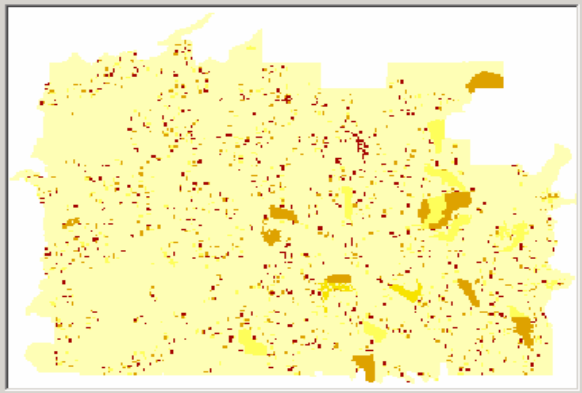
○ Scale 0 -100

	Minimum Age			Maximum Age			ELT		SI 1
≥	0	<	1	and	1	=	0.0		
≥	1	<	21	and	1	=	1.0		
≥	21	<	31	and	1	=	0.8		
≥	31	<	41	and	1	=	0.5		
≥	41	<	500	and	1	=	0.3		
≥	0	<	1	and	2	=	0.0		
≥	1	<	11	and	2	=	1.0		
≥	11	<	21	and	2	=	0.5		
≥	21	<	31	and	2	=	0.1		
≥	31	<	500	and	2	=	0.0		
≥	0	<	1	and	3	=	0.0		
≥	1	<	11	and	3	=	0.5		
≥	11	<	21	and	3	=	0.1		
≥	21	<	500	and	3	=	0.0		
≥	0	<	500	and	0	=	0.0		
≥		<		and		=			
≥		<		and		=			
≥		<		and		=			

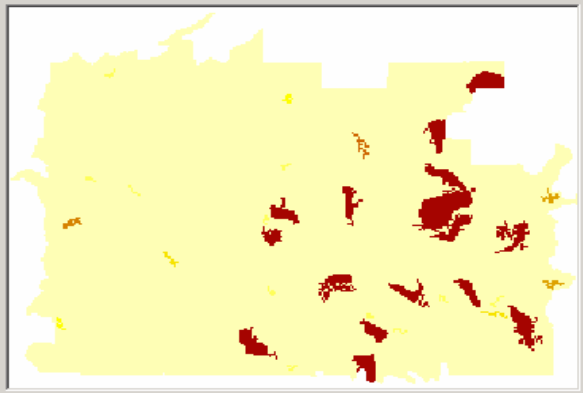
HSImodels - [Prairie Warbler HSI Model]

File View Models Window Help

Prairie Warbler SI 1 | Prairie Warbler SI 2 | Prairie Warbler SI 3 | Prairie Warbler HSI



SI 1



Calculate SI 2

☐ Write Output File

◉ Scale 0.0 - 1.0

○ Scale 0 -100

Values in SI 1 > 0.0 will be considered a patch.

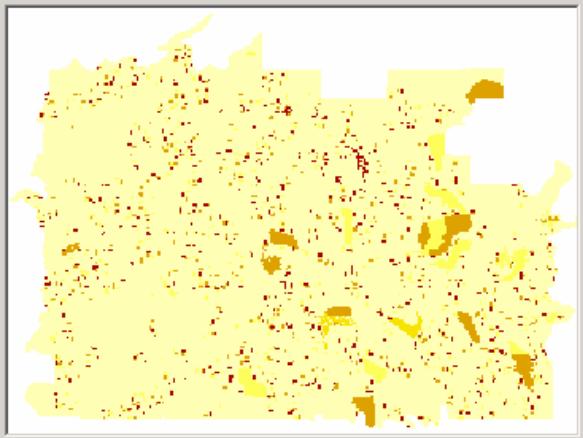
Patch Size in Hectares

If patch	≥	0.00	and <	0.41	then SI2 =	0.0
If patch	≥	0.41	and <	3.43	then SI2 =	(0.32 * PATCHSIZE) - 0.13
If patch	≥	3.43	and <	1000000	then SI2 =	1.0
If patch	≥		and <		then SI2 =	

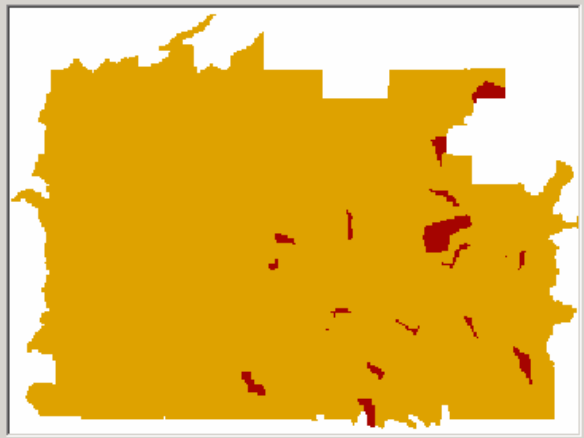
HSImodels - [Prairie Warbler HSI Model]

File View Models Window Help

Prairie Warbler SI 1 | Prairie Warbler SI 2 | **Prairie Warbler SI 3** | Prairie Warbler HSI



SI 1



Calculate SI 3

☐ Write Output File

◉ Scale 0.0 - 1.0

○ Scale 0 -100

Decision Rule

If Minimum ≥ 0.0 and < 0.01

Then SI 3 = 0.5

Else SI 3 = 1.0

Moving Window

○ Circle

◉ Square

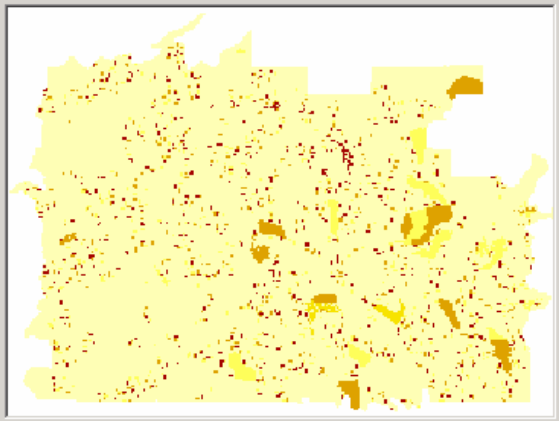
Radius in Pixels

3 Side of Square

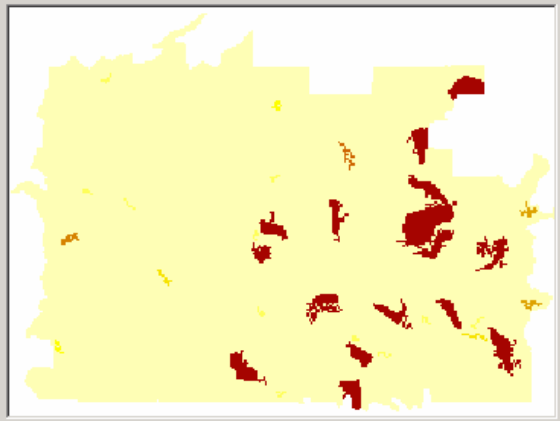
HSImodels - [Prairie Warbler HSI Model]

File View Models Window Help

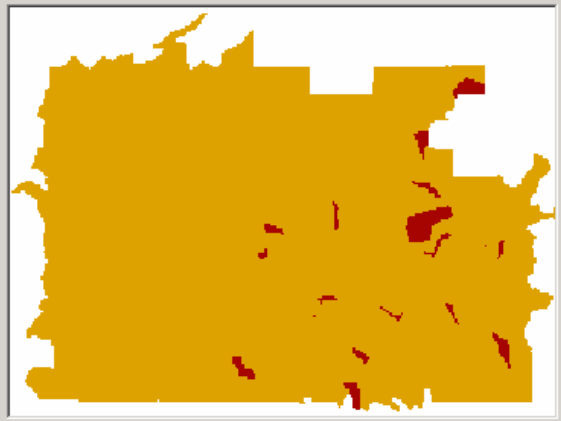
Prairie Warbler SI 1 | Prairie Warbler SI 2 | Prairie Warbler SI 3 | Prairie Warbler HSI



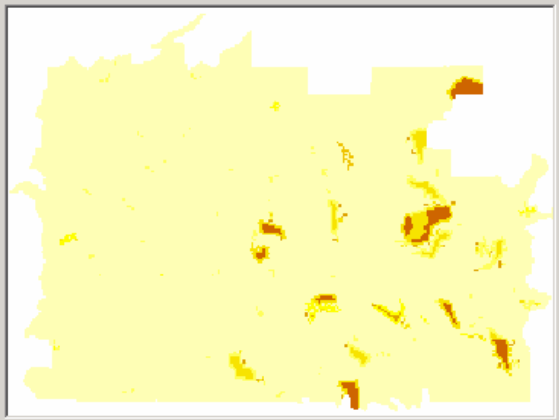
SI 1



SI 2



SI 3



Calculate HSI

HSI Equation

POW ((SI1 * SI2) , 0.5) * SI3

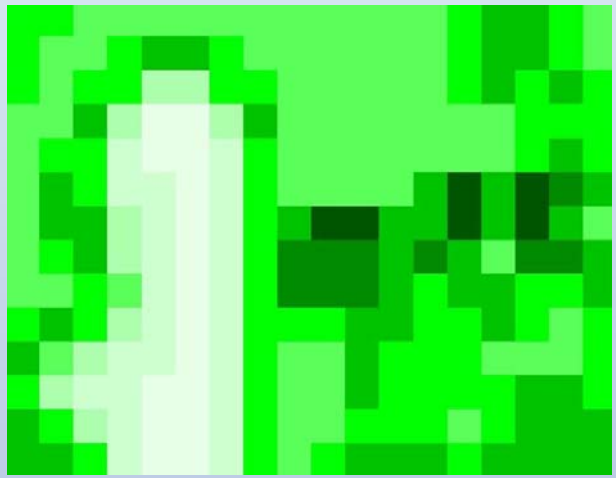
☐ Write Output File

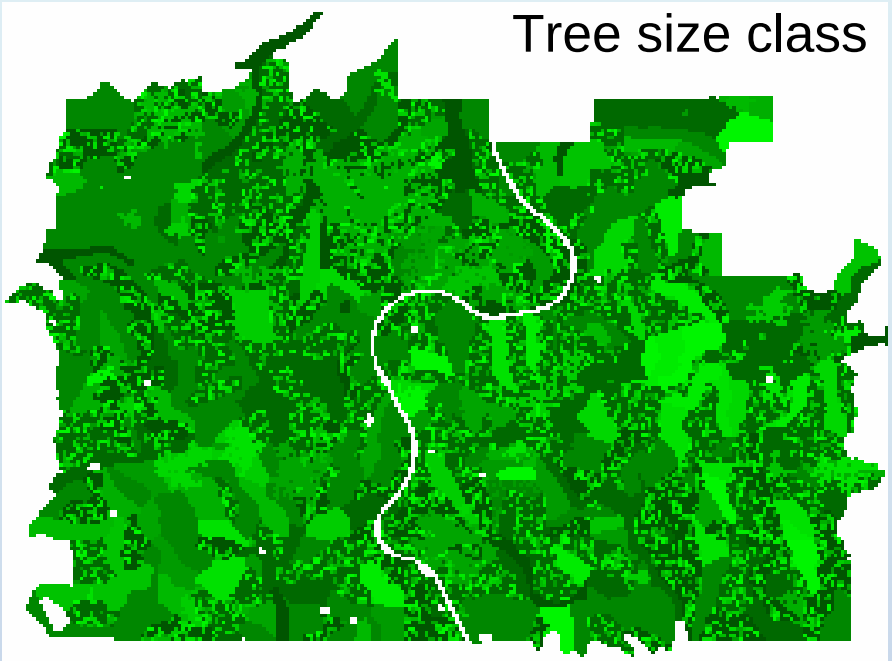
◉ Scale 0.0 - 1.0

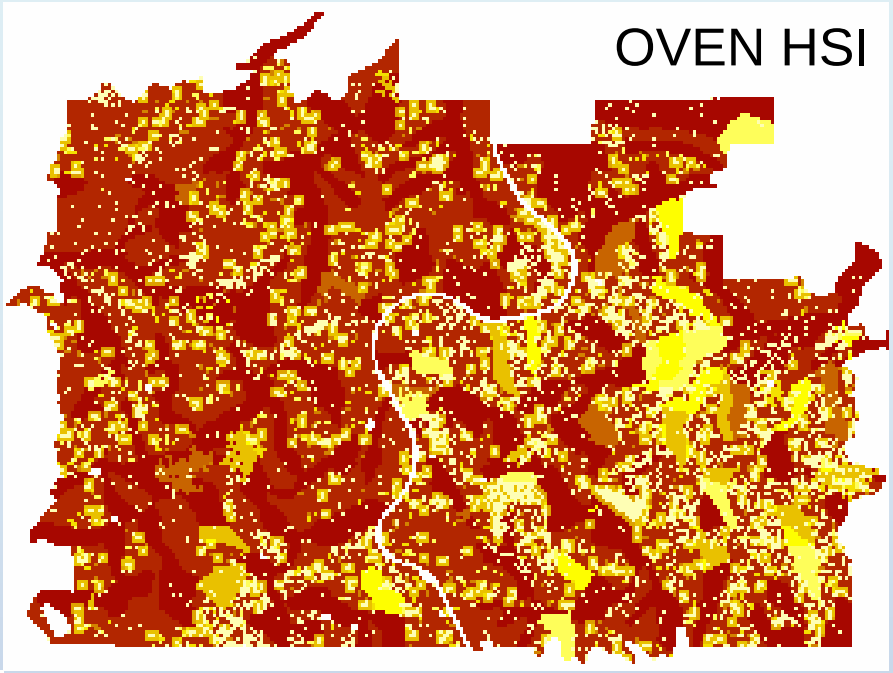
○ Scale 0 -100

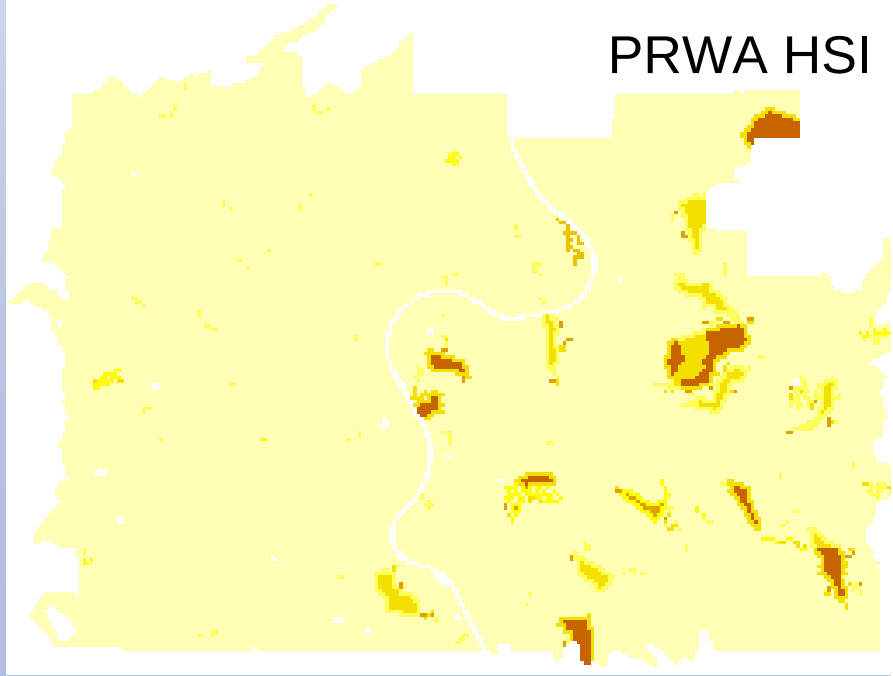
Summarizing HSI values for a landscape

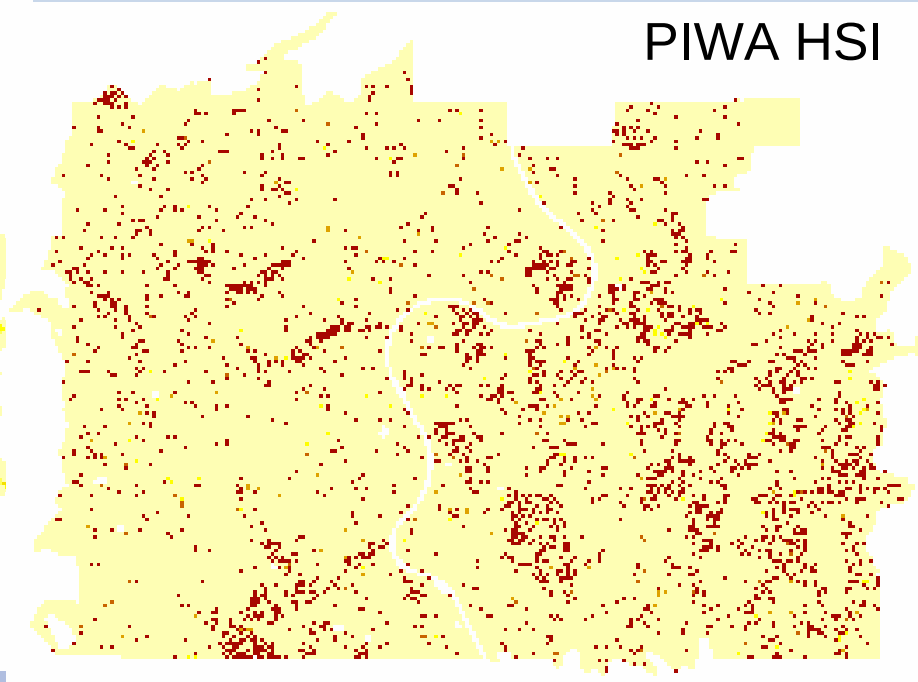
- Maps
- Descriptive statistics
  (mean, median, sum)
- Frequency distributions
- Input to other programs that map home ranges, model population dynamics



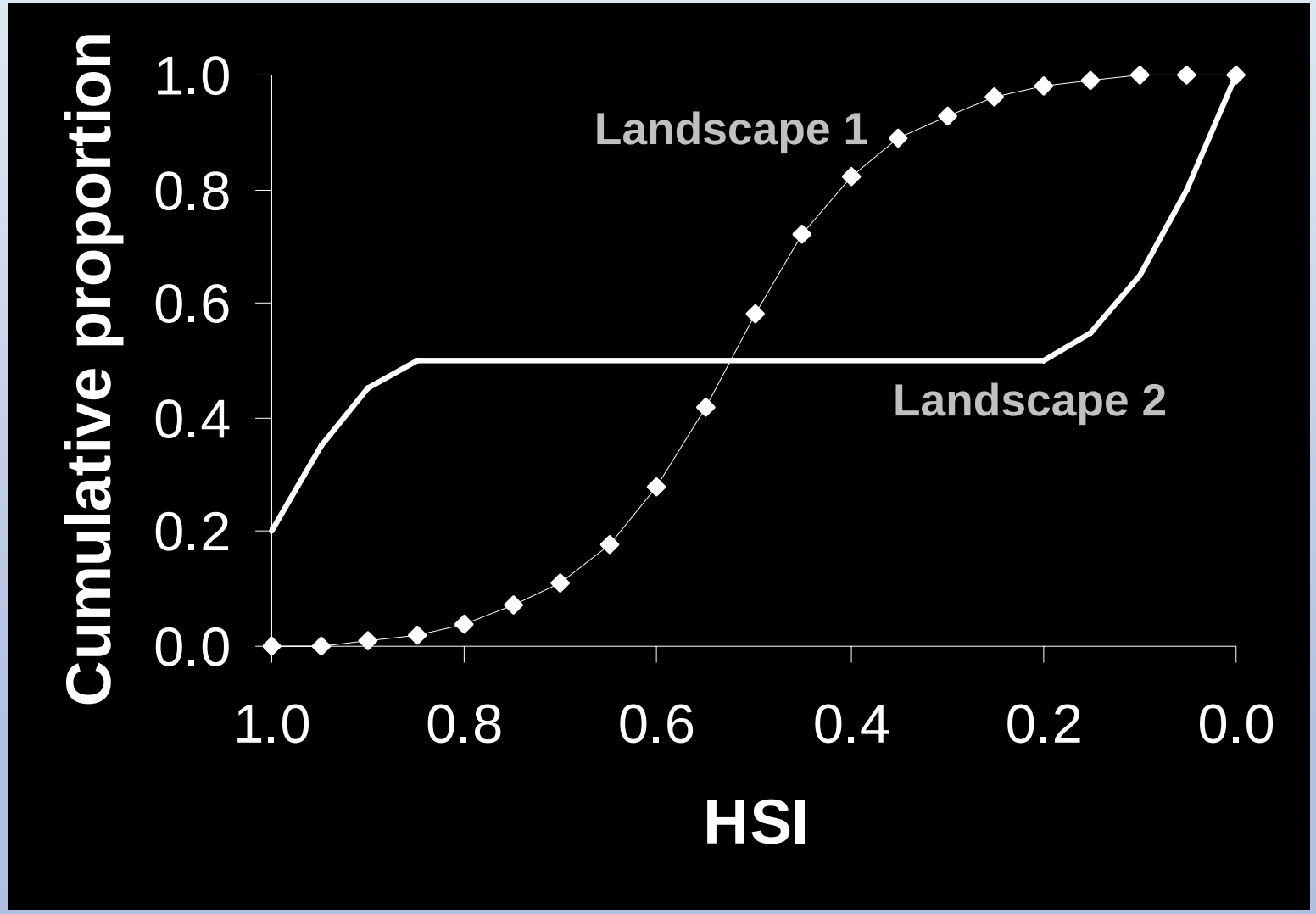

Tree size class


OVEN HSI

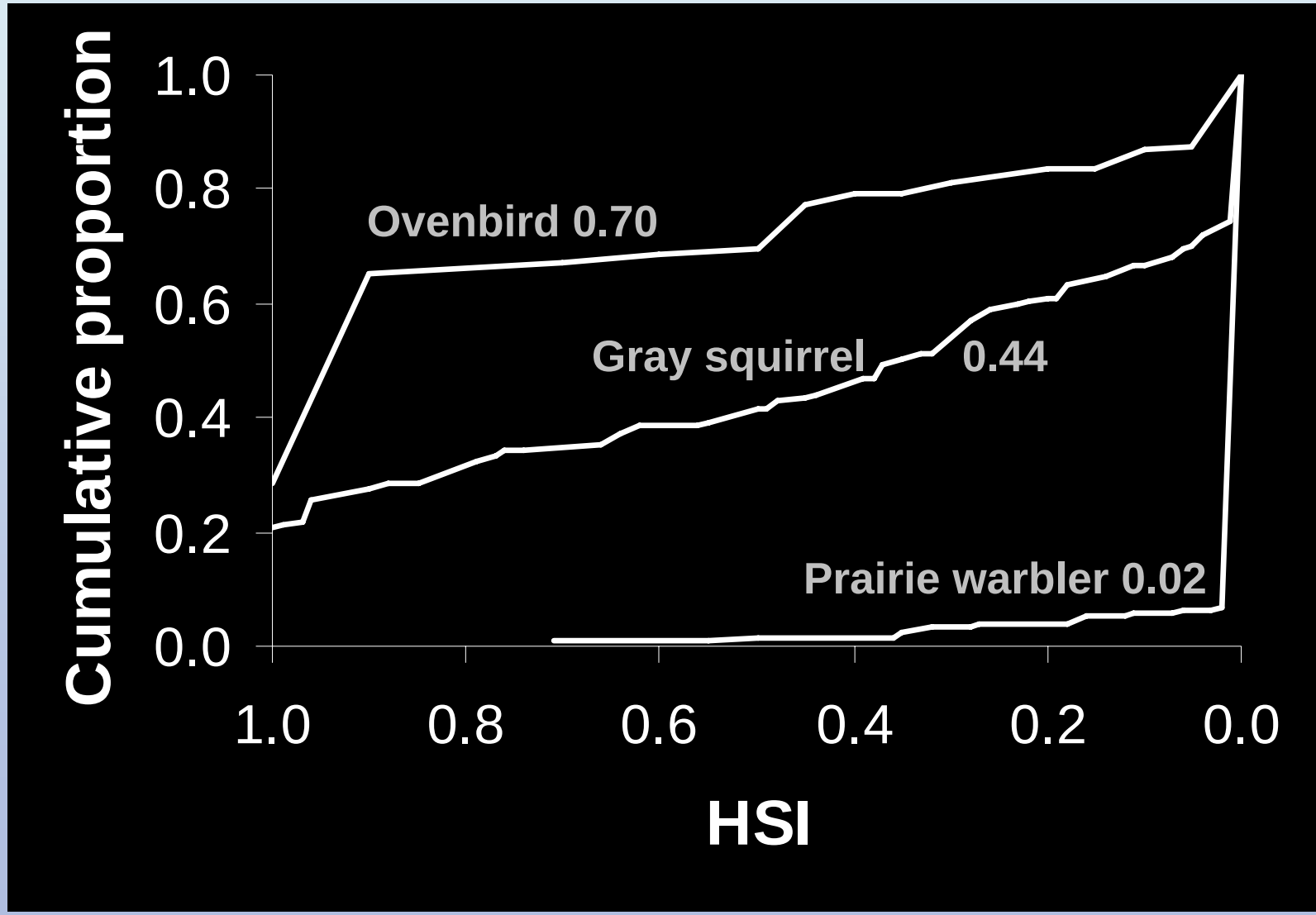

PRWA HSI

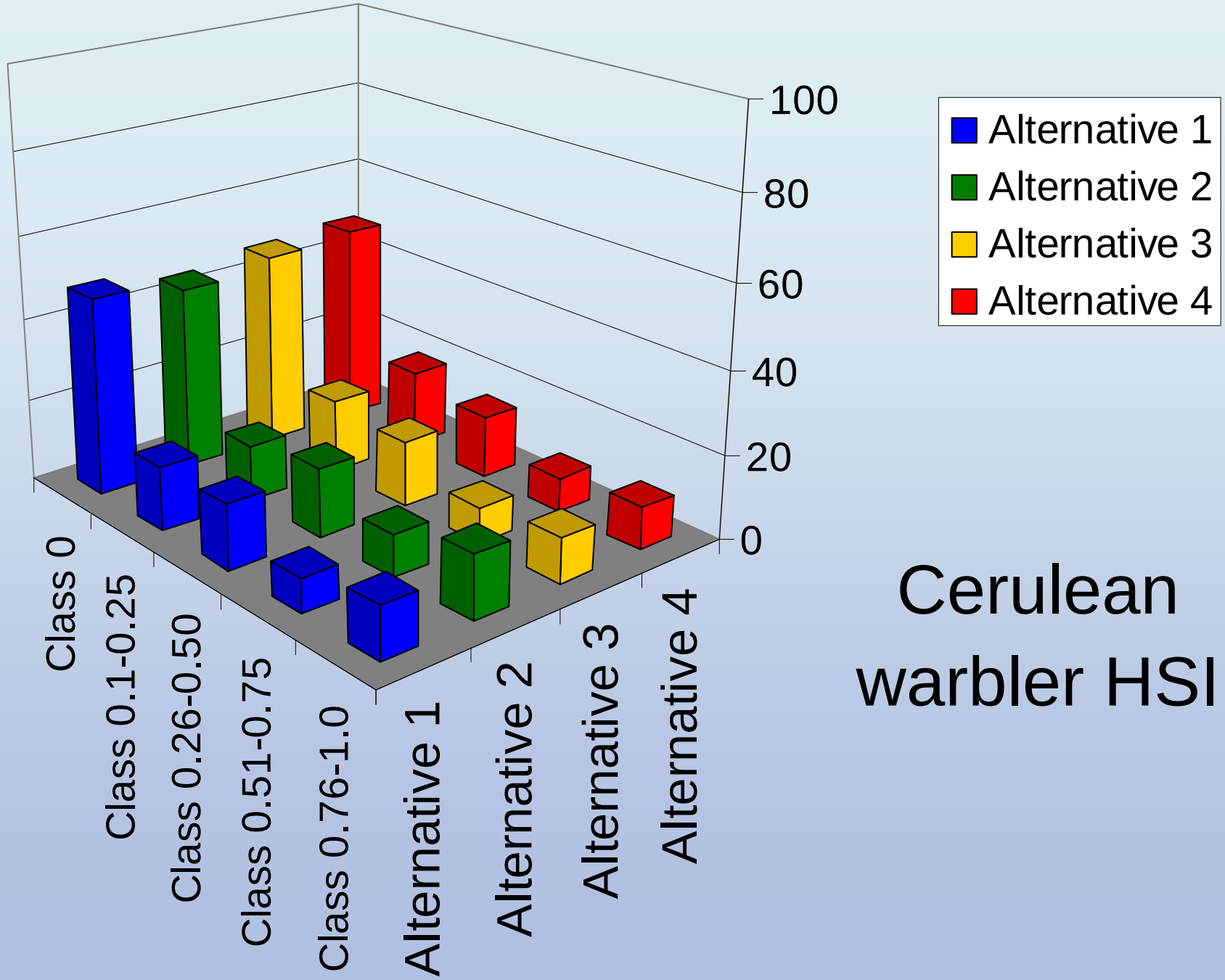

PIWA HSI

Summarizing HSI values for a landscape



Summarizing HSI values for a landscape





Cerulean warbler HSI

Summarizing HSI values for a landscape

- Input to other models
  - Link HSI values to density
    - directly with data
    - map territories
  - Use HSI maps as input to spatially explicit population models

HSI modeling approaches

- Can be developed from existing knowledge or data which can include data, published knowledge, and expert opinion. (+)
- Can use multiple sources of information for SIs or multiple scales within a model. (+)
- Models can be developed for at any desired scale as long as have hypotheses for that scale. (+)
- Can adapt habitat relationships from research studies to available data sources for conservation planning. (+)

HSI modeling approaches

- Predict habitat suitability or quality, not necessarily abundance or density. (+ or -)
- Methods for weighting and combining habitat and landscape factors (suitability indices) are somewhat ad-hoc. (-)
- Models are based on hypotheses (+)
- Models are essentially hypotheses until validated (-)